ŏ.

	Millimeter.	
Distance apart.....	1.011	Mean of eight observations.

ŭ.

Distance apart.....	1.5561	Mean of eight measurements.

It would be well if a material could be discovered soft enough to offer the minimum resistance to the excavating action of the stylus, yet which could be hardened without distorting the shape of the depression.

Some Tables for the Interconversion of Metric and English Units.

By Persifor Frazer, Jr., A. M.

(*Read before the American Philosophical Society, April* 5, 1878.)

Capt. Kater, in 1821, as a member of the Royal Standard's Commission, appointed in 1818, made the determination of the meter to be 39.37079 inches. This was adopted by the Commission and was embodied into the statute of the British Parliament enacted in 1824, establishing the platinum standard meter in Paris as in length equal to 39.3708 inches of brass at the temperature of 62° Fahrenheit, the platinum standard being at 0° Centigrade, or 32° Fahrenheit, the temperature of melting ice.

Capt. Kater's value was again sanctioned by law in 1864.*

In 1866, the Royal Ordinance Survey, adopted 1 meter = 39.370432 inches, on the authority of Col. (then Capt.) A. R. Clarke, Superintendent of the Office of the Survey at Southhampton.

In 1869, the more recent Royal Standard's Commission, under the Presidency of Astronomer Royal Airey, reported comparative tables, founded on Kater's value, which were published in a Parliamentary Blue Book, and may be found at the end of the second Report of the Royal Standard's Commission, published in that year.†

The subjoined work was undertaken to supply a want which every physicist and chemist, and, indeed, very many artisans and manufacturers have felt, for a set of convenient and consistent tables for converting various values of measure and weight from one into the other of the two systems between which at present the calculations of the greater part of the civilized world, both in science and trade, are divided.

Every one knows that a multitude of tables for this object are already in

* When the use of the metric sytem was rendered permissive in Great Britain so far as related to contracts.

† Extracts from a private letter from President F. A. P. Barnard, of Columbia College, New York.

existence, yet it must be apparent to any one who has compared them together that there are generally discrepancies between them.

For instance, three authorities which should command the confidence of scientific men give the following values :

	Rankine.	Crookes.	Eliot & Stover.
Grains in a Gram.....	15.43235	15.438395	15.4346
Cubic meters in 1 cubic foot	0.0283153	0.028314	.....
Tonnes in a ton	1.01605	1.015649	.....
Kilos. per sq. centimeter in one pound per sq. inch..	.0703095	.0702774	.....

Only three authorities are here quoted, but the number might be almost indefinitely increased. It is true that for most purposes these differences being less than one thousandth of one per cent., would not seriously affect the results ; but there are problems continually occurring where some recognized equivalent is most desirable, and still a greater number where it is desirable that all the diverse terms employed should have been obtained from the same original unit and by the same methods.

It would be far better that all the English speaking world should accept a wrong determination as the only legal one than that each person who employs such reciprocal values should take a different standard, even if one of the number could be *absolutely* right.

In all questions relating to the value of lineal, superficial and cubical equivalents of the English and Metric units, including those defined by law as a certain whole number and fraction of cubic inches or feet (*e. g.* the bushel, barrel, stone-perch, &c.), the determination of Kater has been taken, and squared, cubed, multiplied and divided until the expression for the desired derivative of the meter was obtained in terms of some derivative of the inch, no decimals having been omitted until the final number was reached ; when the shorter approximative expression has been substituted by an application of the well-known rules governing such cases.

The number of decimal places given has been in proportion to the importance of the unit as a base from which to calculate other values. Thus the number of places in the Grain–Gram equivalents is eleven (as in the report of Mr. Upton, from which it was taken), whilst the Rood–Are being less frequently used and especially being of less importance as a base from which to derive other values, is given in five and six places respectively.

This method of separate calculation from the fundamental Inch-Meter value has been employed for each of the above-mentioned kinds of dimensions, and the value of the metric unit in the Inch derivative has been converted into the reciprocal or Inch derivative unit by simply dividing the whole decimal into one and shortening as before. This is obviously to be preferred to taking the reciprocal of the legal value of the meter in inches, as the base of the calculation.

Crookes' (Select Method of Chemical Analysis) was drawn on for the

form of expressing the Fahrenheit in the Centigrade degree. Rankine is responsible for the statement of the relation between English Heat Units and French Calories, but both have been verified.

In weight the fundamental units (the value of the Gram. in Grains) is taken from the report of Mr. Upton (Chief Clerk of the Treasury) to Hon. John Sherman, Secretary, March 26, 1878, and from this value all the others were calculated.

In fine, all the values here appended have been as carefully as possible revised by the author, and, in addition, have had the benefit of the very valuable criticism and corrections of Professor Chase, of Haverford College, and of President Barnard, of Columbia College, the latter of whom has conferred greater security in verifying them by the calculating machine.

In the case of lineal units, four of those most constantly recurring were selected, and the values of one up to nine times each unit are given in terms of the other. This method, which is employed in Crookes' "Select Methods of Chemical Analysis" (London, 1871,) permits any decimal multiple or fraction of one unit to be obtained with great accuracy in terms of the other, by a change of the decimal point and a simple addition.

Thus, if it be required to find the number of inches in $348\frac{1}{5}$ centimeters, the fraction would first be written decimally, 348.16. The value in inches of three centimeters is 1.181124.

				INCHES.
300	centimeters	would	equal.....	118.1124
40	"	"	"	15.74832
8	"	"	"	3.149663
0.1	"	"	"	0.03937079
0.06	"	"	"	0.02362247
348.16	"	"	"	137.07337626

For area, capacity and weight, the value of only one unit of each is given in terms of the other, and a simple multiplication will give any number of times such an unit.

The value of the meter in inches is given by Mr. Upton, Chief Clerk of Treasury Department, in the report before mentioned, as 39.370432, and consequently the values here given do not agree with those for length, area, surface or capacity in that report.

The same unit which he gives for the gram in grains is adopted here, so that the column of weights should accord.

TABLES

FOR THE

INTERCONVERSION

OF

ENGLISH AND METRIC UNITS.

BY

Persifor Frazer, Jr., A.M..

Presented to Am. Philosophical Society, April 5, 1878.

PHILADELPHIA.

1 cubic inch water weighs = 252.7574 grains.
At max. dens., Bar. 30 in. Air 62° F. (Barnard.)
1 cubic foot water weighs = 62.3949696 lbs.
1 cwt. (112 lbs.) = 50.80238 kilos.
Quarter (28 lbs.) = 12.700595 "
Drachm = 1.77185 grams.

LINEAL UNITS.

INCHES.		CENTIMETERS.	FEET.		METERS.
0.3937079	=	1	1	=	0.3047945
1	=	2.539954	3.2809	=	1
0.787416	=	2	2	=	0.6095890
2	=	5.0799	6.5618	=	2
1.181124	=	3	3	=	0.9143835
3	=	7.6199	9.8427	=	3
1.574832	=	4	4	=	1.2191780
4	=	10.1598	13.1236	=	4
1.968539	=	5	5	=	1.5239724
5	=	12.6998	16.4045	=	5
2.362247	=	6	6	=	1.8287669
6	=	15.2397	19.6854	=	6
2.755955	=	7	7	=	2.1335614
7	=	17.7797	22.9663	=	7
3.149663	=	8	8	=	2.4383559
8	=	20.3196	26.2472	=	8
3.543371	=	9	9	=	2.7431504
9	=	22.8596	29.5281	=	9

LINEAL UNITS.

YARDS		METERS.	MILES.		KILOMETERS.
1	=	0.9143835	0.6214	=	1
1.093633	=	1	1	=	1.6093
2	=	1.8287669	1.2428	=	2
2.1873	=	2	2	=	3.2186
3	=	2.7431504	1.8641	=	3
3.2809	=	3	3	=	4.8279
4	=	3.6575340	2.4855	=	4
4.3745	=	4	4	=	6.4373
5	=	4.5719174	3.1069	=	5
5.4682	=	5	5	=	8.0466
6	=	5.4863009	3.7283	=	6
6.5618	=	6	6	=	9.6559
7	=	6.4006845	4.3497	=	7
7.6554	=	7	7	=	11.2652
8	=	7.315068	4.9711	=	8
8.7491	=	8	8	=	12.8745
9	=	8.2294514	5.5924	=	9
9.8427	=	9	9	=	14.4838

AREA.

SQ. INCH.		SQ. CENTIMETER	SQ. FEET.		SQ. METER.
1	=	6.451367	1	=	0.09290
0.1550059	=	1	10.76393	=	1

SQ. YARD.		SQ. METER.	SQ. YARDS.		ARE.
1	=	0.8360972	1	=	0.00836097
1.19603326	=	1	119.603326	=	1

ROOD.		ARE.	ACRE.		HECTARE.
1	=	10.11678	1	=	0.404671
0.098845	=	1	2.471143	=	1

THERMOMETER. FAHRENHEIT DEGREES.		THERMOMETER. CENTIGRADE DEGREES.	HEAT UNITS. 1 LB. WATER 1° FAH.		CALORIES 1 KILOGRAM WATER 1° CEN.
1	=	0.55556	3.96832	=	1
1.8	=	1	1	=	0.251996

CAPACITY.

CUBIC INCHES.		CUBIC CENTIMETERS.	CUBIC FOOT.		CUBIC DECIMETER. (Liter.)
1	=	16.38617589	1	=	28.315312
0.06102705152	=	1	0.03531658	=	1

CAPACITY.

CUBIC FT.		CUBIC M. (Stere.)	CUBIC YD.		CUBIC M. (Stere.)
1	=	0.028315	1	=	0.764513470
35.31658	=	1	1.3080215	=	1

MINIM.		CUB. CENT. M.	FLUID OZ.		CUB. CENT. M.
1	=	0.0616082	1	=	29.5719289
16.23158	=	1	0.033815	=	1

U. S. FINT. (WINE).		LITER.	U. S. GAL. 231 C. I.		LITER.
1	=	0.47315083	1	=	3.7852067
2.1134908	=	1 a	0.264186	=	1

U. S. WINE BL. (31.5 Gals.)		LITER.	GAL. (IMP.)		LITER.
1	=	119.234017	1	=	4.54345728
0.00838686	=	1	0.2200967	=	1

U. S. BUSHEL. (2150.42 C. I.)		LITER.	CORD.		STERE. (Cubic Meter.)
1	=	35.2371556	1	=	3.624360
0.028379135	=	1	0.275911	=	1

SOLID PERCH. (25 CUB. FT.)		CUBIC M. (Stere.)
1	=	0.7078828
1.412663	=	1

WEIGHT.

POUNDS TO FOOT.		KILOS TO METER.	POUNDS TO SQ. INCH.		KILOS TO SQ. CENTIMETER.
1	=	1.48819	1	=	0.0703096
0.6719572	=	1	14.22282	=	1

GRAINS.		GRAMS.	POUNDS. (Av.)		KILOGRAMS.
1	=	0.064798 95036	1	=	0.453592653
15.43234874	=	1	2.2046212	=	1

OZ. (AV.)		GRAMS.	LBS. TROY.		KILOGRAMS.
1	=	28.349541	1	=	0.373241954
0.035274	=	1	2.679227	=	1

TONS.		TONNES. (1000 kilos.)
Long (2240 lbs.)	=	1.0160475
Short (2000 lbs.)	=	0.9071853
Long. 0.9842059) Short 1.1023105)	=	1

GRAINS PER U. S. GALLON.		MILLIGRAMS PER LITER.	FOOT. POUNDS.		KILOGRAMETER.
1	=	17.1189987	1	=	0.138253
0.05841463	=	1	7.23314	=	1